8-2015

Farmers and Climate Change: A Cross-National Comparison of Beliefs and Risk Perceptions in High-Income Countries

Linda S. Prokopy
Purdue University

J. Gordon Arbuckle
Iowa State University, arbuckle@iastate.edu

Andrew P. Barnes
Scottish Royal College

V. R. Haden
The Ohio State University

Anthony Hogan
University of Canberra

See next page for additional authors

Farmers and Climate Change: A Cross-National Comparison of Beliefs and Risk Perceptions in High-Income Countries

Abstract

Climate change has serious implications for the agricultural industry—both in terms of the need to adapt to a changing climate and to modify practices to mitigate for the impacts of climate change. In high-income countries where farming tends to be very intensive and large scale, it is important to understand farmers' beliefs and concerns about climate change in order to develop appropriate policies and communication strategies. Looking across six study sites—Scotland, Midwestern United States, California, Australia, and two locations in New Zealand—this paper finds that over half of farmers in each location believe that climate change is occurring. However, there is a wide range of beliefs regarding the anthropogenic nature of climate change; only in Australia do a majority of farmers believe that climate change is anthropogenic. In all locations, a majority of farmers believe that climate change is not a threat to local agriculture. The different policy contexts and existing impacts from climate change are discussed as possible reasons for the variation in beliefs. This study compared varying surveys from the different locations and concludes that survey research on farmers and climate change in diverse locations should strive to include common questions to facilitate comparisons.

Keywords

climate change, farmers, beliefs, risk perceptions, surveys, agriculture

Disciplines

Agriculture | Climate | Natural Resources and Conservation | Rural Sociology

Comments

This is a manuscript of an article published as Prokopy, Linda S., J. G. Arbuckle, Andrew P. Barnes, V. R. Haden, Anthony Hogan, Meredith T. Niles, and John Tyndall. "Farmers and climate change: A cross-national comparison of beliefs and risk perceptions in high-income countries." *Environmental management* 56, no. 2 (2015): 492-504. doi: 10.1007/s00267-015-0504-2. Posted with permission.

Authors

Linda S. Prokopy, J. Gordon Arbuckle, Andrew P. Barnes, V. R. Haden, Anthony Hogan, Meredith T. Niles, and John Tyndall

Title: Farmers and Climate Change: A Cross-National Comparison of Beliefs and Risk Perceptions in High-Income Countries

Authors: Linda S. Prokopy[1], J. G. Arbuckle[2], Andrew P. Barnes[3], V. R. Haden[4], Anthony Hogan[5], Meredith T. Niles[6], John Tyndall[7]

[1]**Correponding Author:** Linda S. Prokopy, Purdue University, 195 Marsteller Street, West Lafayette, IN 47906, USA; lprokopy@purdue.edu; (tel) +1-765-496-2221; (fax) +1-765-496-2422

[2] J.G. Arbuckle, Iowa State University, 303c East Hall, Ames, IA 50011, USA; Arbuckle@iastate.edu

[3] Andrew P. Barnes, Scottish Rural College, SRUC Edinburgh Campus, King's Buildings, West Mains Road, Edinburgh, EH9 3JG, Scotland; Andrew.barnes@sruc.ac.uk

[4] V.R. Haden, The Ohio State University, 1328 Dover Rd., Wooster, OH 44691, USA; haden.9@osu.edu

[5] Anthony Hogan, University of Canberra, The Innovation Centre, Building 23, Level B, Canberra, Australia; Anthony.Hogan@canberra.edu.au

[6] Meredith T. Niles, Harvard University, 79 JFK Street, Cambridge, MA 02138, USA; Meredith_Niles@hks.harvard.edu

[7] John Tyndall, Iowa State University, 238 Science II, Ames, IA 50011, USA; jtyndall@iastate.edu

Acknowledgments: The survey of Midwestern corn producers was developed through a collaboration of two United States Department of Agriculture National Institute for Food and Agriculture (USDA-NIFA)-supported projects, Cropping Systems Coordinated Agricultural Project (CAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems (Award No. 2011-68002-30190) and Useful to Usable (U2U): Transforming Climate Variability and Change Information for Cereal Crop Producers (Award No. 2011-68002-30220). Additional funding was provided by the Iowa Agriculture and Home Economics Experiment Station, Purdue University College of Agriculture, and the Iowa Natural Resources Conservation Service. The California Energy Commission (grant # CEC-500-2012-032) provided funding for the California study and we would like to thank Mark Lubell and Louise Jackson for their insights on this survey. This survey and research on Scottish dairy farming was supported by the European Commission Animal Change project (contract no. KBBE-266018) and the Scottish Government Research

Programmes into Food and Economic Adaptation. We would like to thank Luiza Toma for her assistance on the Scottish questionnaire. Funding for the New Zealand survey and research was provided by AgResearch, Ltd., the United States National Science Foundation Graduate Research Program and the United States National Science Foundation Responding to Rapid Environmental Change IGERT program grant NSF- DGE#0801430. We thank Robyn Dynes and Margaret Brown for their insights on the New Zealand survey. The Rural Industries Research and Development Corporation, Canberra, Australia supported the Australian survey.

Title: Farmers and Climate Change: A Cross-National Comparison of Beliefs and Risk Perceptions in High-Income Countries

Abstract: Climate change has serious implications for the agricultural industry – both in terms of the need to adapt to a changing climate and to modify practices to mitigate for the impacts of climate change. In high-income countries where farming tends to be very intensive and large-scale, it is important to understand farmers' beliefs and concerns about climate change in order to develop appropriate policies and communication strategies. Looking across six study sites - Scotland, Midwestern United States, California, Australia and two locations in New Zealand - this paper finds that over half of farmers in each location believe that climate change is occurring. However there is a wide range of beliefs regarding the anthropogenic nature of climate change; only in Australia do a majority of farmers believe that climate change is anthropogenic. In all locations, a majority of farmers believe that climate change is not a threat to local agriculture. The different policy contexts and existing impacts from climate change are discussed as possible reasons for the variation in beliefs. This study compared varying surveys from the different locations and concludes that survey research on farmers and climate change in diverse locations should strive to include common questions to facilitate comparisons.

Keywords: climate change; farmers; beliefs; risk perceptions; surveys; agriculture

1. Introduction

Global climate change is widely viewed as one of society's most significant challenges. There is substantial evidence that climate change poses a credible and mounting threat to the production of food, feed, fuel and fiber worldwide (Howden et al. 2007; Brown and Funk 2008; Lobell and Gourdj 2012; Walthall et al. 2012). While the scope and scale of these impacts remain uncertain, efforts to adapt agricultural practices and policies to shifting climate patterns will be needed to safeguard food security, enhance the resilience of agroecological systems, and take advantage of new market opportunities and technological innovation (Smit and Skinner 2002; Adger et al. 2005; IPCC 2007; Lobell et al. 2008). Agriculture also exacerbates climate change by releasing greenhouse gases (GHGs) into the atmosphere, with agricultural sources accounting for 10-12% of global anthropogenic emissions each year (IPCC 2007). Consequently, agriculture offers key opportunities to mitigate the cause of climate change through agricultural practices and land use decisions that reduce emissions from soil and fossil fuels or that sequester carbon in soil and plant biomass (Lal et al. 2011). In effect, agriculture is presented with the dual challenge of learning to cope with consequences of climate change through adaptation, while also addressing its root cause, GHGs, via mitigation (Smith and Olesen 2010; Beddington et al. 2012).

Because agriculture is both vulnerable to changes in climate and a significant source of GHGs (Beddington et al, 2012; IPCC 2007; NRC 2010), calls for coordinated adaptation and mitigation initiatives are on the rise (e.g., Coumou and Rahmstorf 2012; Howden et al. 2007; McCarl 2010). Given that the success of these initiatives will require active participation of rural communities and individual farmers, there is a pressing need to understand how farmers' beliefs and concerns about climate change influence their adaptation and mitigation behaviors (Arbuckle et al. 2013; Haden et al. 2012). It is known that propensity to act in response to potential natural hazards can depend largely on beliefs about the existence of the hazard and the perceptions of risks associated with it (Nigg and Mileti 2002). A great deal of work has been undertaken in low-income countries to understand what farmers believe about climate change and their perceptions of climate risks (see e.g. Deressa et al. 2011; Gwimbi 2009; Maddison 2007) but less work has been conducted within high-income countries where agricultural systems can be quite different in scale and scope. Understanding what high-income country farmers believe about climate change and their risk perceptions will help to inform future mitigation and adaptation strategies in those regions of the world. In this paper we examine farmers' beliefs about climate change, perceived risks, and attitudes towards adaptation and mitigation in six different high-income locations and examine whether these beliefs are associated with location-specific variables such as policies and existing impacts from climate change.

A review of the literature on farmers' beliefs about climate change reveals little work from high-income countries prior to 2010 when our work started to come out in the literature (but see Bryant et al. 2000 for a review of Canadian studies and Harrington and Lu (2002) with evidence from Kansas, United States). An emerging number of studies are now appearing (e.g. Gramig et al. 2013; Rejesus et al. 2013; Wheeler et al. 2013) but these are still limited compared to the numbers of studies in low-income regions of the world like parts of Asia and Africa. As noted by Brown and Funk (2008), the impacts of climate change on subsistence farmers is likely to be much more extreme due both to more immediate and extreme temperature and precipitation changes and due to the lack of infrastructure and adaptation options in these locations. However, farmers in high-income countries are also vulnerable to a changing climate as increasing temperatures and changing precipitation patterns threaten both crop yields and animal welfare. Additionally, farmers in high-income countries control a large portion of land and can have significant potential to perform climate change mitigation practices. The food they grow feeds a large portion of the world as well as mediates regional economic development and successful adaptation is essential for global food security, environmental quality, and regional economic health (OECD 2013).

2. Study Locations

The survey-based studies reviewed in this synthesis occurred at six different locations (see Table 1). These represent a range of industrialized agricultural systems operating under a variety of support systems for agricultural production and governance structures with respect to climate change related policies. Our locations include Scotland, Australia, New Zealand (two unique locations), and California and the "Midwest" in the United States. While the primary agricultural sector in all of these locations only provides relatively small contributions to respective national economies, in general the farms are much larger in scale than in low-income countries where these types of studies are frequently conducted (see for example Gbetibouo 2009; Gwimbi 2009; Mertz et al. 2008). The farmer surveys were all conducted for different purposes in these regions but contained similar enough questions that a comparison is useful and informative. The information analyzed in this review covers farmer perspectives across a range of production types and markets. Table 1 shows key comparisons between these locations. Further information about the details of each of the studies is available elsewhere (Australia – Hogan et al. 2011; California – Haden et al. 2012; Niles et al. 2013a; Midwestern US – Arbuckle et al. 2013; New Zealand – Niles et al. 2013a; Scotland – Barnes and Toma 2012).

2.1 Agricultural Context

The role of agriculture in each study location's economy varies (see Table 1). Agricultural Gross Domestic Product (GDP) is one measure of the impact of agriculture on a country's economy and captures percent share of overall GDP that is attributable from this sector. It is lowest in the US and UK (1.1% and 0.7% of GDP respectively) and highest in Australia and New Zealand (4% and 4.8% of GDP respectively). While GDP contribution may appear low, all of these locations are significant producers of food and fiber. The percent of total greenhouse gas emissions from agriculture varies greatly across the countries. The US is lowest at 6.9% and New Zealand has by far the greatest share of GHG emissions from agriculture at 47.2%. The area of the US Midwest that was surveyed comprises nearly 51.4 million hectares of farmland that produces nearly 60 percent of the US corn and soybean crop (USDA NASS 2009). The land area of the California survey covered a total of 265,000 hectares in Yolo County containing 131,000 hectares of irrigated cropland and 55,000 hectares of rangeland (Haden et al., 2013). In the two regions in New Zealand, agriculture encompasses 65% percent of total land in the Hawkes Bay and 49% in Marlborough (Hawkes Bay Regional Council; Marlborough District Council; Statistics New

Zealand 2012). The Australia survey covered the entire country. Within Scotland, the total area attributed to agricultural holdings is 5.6 million hectares, equating to 73 per cent of Scotland's total land area (RESAS 2013).

There is a diversity of agriculture in all the studied locations. The focus of each study differed, however, and this impacted the types of farms and farmers represented in our synthesis. In Australia, New Zealand and California, all types of agricultural producers were surveyed. As noted in Table 1, there were dominant farm types in the two regions in New Zealand but this was not the case in Australia and California. Conversely, in the Midwestern US and Scotland only large-scale corn producers and dairy farmers, respectively, were surveyed. While these farmers may also conduct other types of agriculture, they were selected for the surveys based on their level of specialization within these two enterprises.

2.2 Climate Change Impacts

In all the surveyed regions, there are anticipated impacts from global climate change in terms of both increased temperature and changing precipitation patterns. Concurrent with a changing climate, however, has been a rapid change in production technology and adaptation management in some of the study regions; for example cropping and livestock systems are incrementally adapting with new genetics, diversified rotations, shifts in irrigation, expanded availability of weather/climate information systems and tools, and broad availability of policy instruments such as private/ public insurance and conservation programming (e.g., Kingwell 2006; Malcom et al. 2012). Because of these adaptive actions, regional impacts of climate change induced weather trends on yields and farm management costs have been variable. Nevertheless, it is clear that climate change is already challenging agriculture in the study regions, causing small but measureable reductions in the rate of annual yield gains representing potential loss to farmers (Lobell and Field 2007).

In the Central Valley, where the California survey was conducted, increases in average temperature have been larger in the winter months than in the summer months and the overall effects on crop yield and crop selection have not been substantial thus far (Lobell et al. 2007; Jackson et al. 2012). However, this statewide warming trend (0.6-1°C over the last century) has led to a 10% reduction in average Sierra snowpack and a loss of almost 1.85 billion m^3 of snow water storage, which are beginning to impact the timing and volume of water available for irrigation (Barnett et al. 2008; California Department of Water Resources 2008). Global climate models also project that mean annual temperatures in California are likely to increase by 2–6°C by the end of this century (Brekke et al. 2008; Cayan et al. 2008). Projected changes in precipitation are more uncertain both in the direction and magnitude of change across the state, but interannual variability and extreme events are already on the rise and expected to increase further in the coming decades (Cayan et al. 2008, 2010). Several modeling studies suggest that by the later part of this century changes in temperature and precipitation will adversely impact the yield of several of California's high value perennial crops (almonds, walnuts, avocados, grapes, etc.) and shorten the growing season for livestock forage in rangelands (Lobell et al. 2006; Chaplin-Kramer and George 2013).

In the Midwestern US, annual mean temperatures have been increasing, which has led to a lengthening of the growing season; this trend is expected to continue. It is expected that this region will also experience increases in seasonal precipitation extremes, higher intensity rain events, higher stream flow, increased summer flooding, and more challenging weed and pest dynamics (Walthall et al., 2013). Such events are expected to negatively impact regional crop yields as well as agricultural revenues (Malcom et al. 2012; Walthall et al. 2013). However, to date corn yields have overall been increasing due to changes in technology and so impacts of climate change may not be apparent to producers (Andresen et al. 2013). That said, experts in the field suggest that, "anticipatory adaptation to climate change is a highly desirable risk-management strategy (Pryor and Barthelmie 2013, p. 247)."

New Zealand's average temperatures have increased by 0.9 °C over the last century and are expected to continue increasing (Clark et al. 2012; Ministry of Environment 2008). Rainfall patterns are projected to change at regional levels with a general trend towards decreasing annual rainfall in the eastern part of the country, including Hawke's Bay and coastal Marlborough, and increasing rainfall in the western parts of the country. Hawke's Bay is expected to see up to a 10% decrease in annual average rainfall (National Institute of Water and Atmosphere 2008), and droughts are predicted to increase in both regions (Ministry for Environment 2008). The pastoral animal systems of New Zealand are likely to be affected by climate change with some net benefits in pasture production, accompanied by seasonal changes that could impact current management strategies. These shifts could result in increased variability of feed supplies and shifts in reproduction timing. Horticultural crops are expected to have various impacts with some crops, like apples, seeing increased yields, while others, including kiwifruit, may suffer from inadequate winter chill hours and subsequently decrease in yields. Grape harvests are expected to occur earlier, and extreme high temperature events may affect wine grape quality and yield (Clark et al. 2012).

Of the locations covered in this analysis, Australia has experienced the most severe impacts attributable to climate change to date. During the first decade of this century, Australia experienced a significant drought. Researchers report "drought in many parts of the country is linked to, or at least exacerbated by, global warming" (Garnaut 2011 p. 108). There are reports that as a result of climate change, droughts have become hotter, with effects on rainfall, evaporation and runoff, and, more generally, water availability for human use (Nicholls 2004). Australia has been experiencing an increased frequency in the number of consecutive hotter days. Temperatures on hot days have been 5-6°C higher, with the heat waves lasting twice as long (e.g. 14 days rather than 7 days) in the summer.

In Scotland, temperatures are predicted to rise, with Southern Scotland expected to experience warming at a faster rate than the North of Scotland (Barnett et al. 2006). Dairy farms, in South-Western

Scotland, have experienced a greater frequency of wet winters and warmer temperatures and these changes are expected to lead to more heat stress related challenges, such as reduced animal weight gain and milk production as well as a higher prevalence of endemic and exotic pests and diseases (Rowlinson 2008; Thornton et al. 2009).

2.3 Policy Environments

This review of policies centers on climate change-relevant policy at various scales (e.g. national, state) that can have direct or indirect effects on farmers' land use behaviors (in both adaptive and mitigative climate change contexts). In all but one of the study locations, there are currently no national or state-level laws that regulate or monitor agriculturally based emissions of GHGs, with the exception being New Zealand. California however, has implemented a cap and trade program that has direct and indirect farm-level implications within the agricultural industry as a whole (Holt and Shobe 2013). In New Zealand, the agricultural sector is required to report GHG emissions through the New Zealand Emissions Trading Scheme (ETS), which became law in September 2008 creating a price-based mechanism for reducing GHG emissions. However, even in New Zealand, individual farms are not targeted and these emissions are reported through agricultural processors (e.g. slaughter facilities, dairy processing facilities, nitrogen fertilizer producers, etc.) and there is no expectation for payment of emissions (Ministry for Agriculture and Forestry 2011). Initially the ETS was intended to more directly target agricultural emissions, but the sector is now exempt from ETS compliance until there are economically viable and practical technologies for biological emission reductions and New Zealand's trading partners make more progress on climate change emissions (Climate Change Response Amendment Act 2012; Ministry for Primary Industries 2013). Notably, costs for agricultural operations have increased through the ETS due to the inclusion of the fuel and transport sectors in July 2010 (Stuff New Zealand Business Day 2010); however, farmers can also earn credits through forestry plantings

(Ministry for the Environment 2012b). It is also important to note that New Zealand does not have agricultural subsidies or incentive programs like all the other study locations.

In California the state legislature passed the Global Warming Solutions Act in 2008. This law aims to reduce California's GHG emissions to 1990 levels by 2020 (CARB 2008). As with New Zealand, large agricultural processing facilities face mandatory reporting and mitigation requirements under the policy, but farmers and livestock managers are currently exempt (CARB 2008; Niemeier and Rowan 2009). California's agriculture and forestry sectors may also be permitted to sell carbon offsets in the statewide cap-and-trade program that is now being implemented by the California Air Resources Board, provided that rigorous offset protocols can be developed and approved for specific mitigation projects (Niemeier and Rowan 2009; Haden et al. 2013).

At this time, Scotland does not directly regulate GHG emissions from agriculture. The Scottish Government has set one of the most ambitious targets for GHG reduction in the world with the 2009 Climate Change Bill, which aims to reduce emissions by 42% of 1990 emission levels by 2020 and by 80% in 2050. In order to reach these goals, the Minister for Environment and Climate Change set targets on an annual basis and, while there are no specific targets directed at dairy operations, livestock is expected to reduce GHG emissions as part of a plan to becoming a low carbon economy (Scottish Government 2013). Additionally, there are two policies in Scotland which are indirectly leading to GHG reductions: (1) Scotland ties subsidy payments to preservation of the environment and landscape features (Dwyer et al., 2008) and (2) farms in Nitrate Vulnerable Zones (NVZs) have strict nitrogen fertilizer management regulations (Barnes et al. 2009). A recent document from the Scottish Government aims for a 90% uptake of nitrogen saving measures within Scottish agriculture (Scottish Government 2013).

In the remaining study locations (Australia and US Midwest), there are federal and state policies that can influence agricultural markets and/or otherwise incentivize farm-scale land use and management that can mitigate GHG emissions and influence the adaptation of farm systems to climate change mediated weather patterns. In Australia, there are government policies to cut GHG emissions by initially putting a fixed price for carbon emissions (which was changed to a market price in 2013) for industries that significantly contributed to carbon emissions (Clean Energy Future 2012); agriculture was exempt from this system. Australia has a voluntary Carbon Farming Initiative scheme (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education 2013). The Initiative 'allows farmers and land managers to earn carbon credits by storing carbon or reducing greenhouse gas emissions on the land. These credits can then be sold to people and businesses wishing to offset their emissions'.

Some of the federal bills that indirectly influence GHG emissions from agriculture in the United Sates include the US Energy Bill (through Renewable Fuel Standard (RFS2)), the Farm Bill, and state Renewable Portfolio Standards (RPS). The RFS2 has an impact on the number of total acres planted to corn and dedication of acres for perennial vegetation (Schnepf and Yacobucci 2013). The Biomass Crop Assistance Program (BCAP) in the Farm Bill incentivizes planting of perennial vegetation (Stubbs 2010); currently there are just over 20,000 hectares of farmland enrolled to produce dedicated energy crops (USDA FSA 2013). Conservation Programs through the Farm Bill incentivize adoption of conservation practices that can help farmers adapt to and mitigate the impacts of climate change. Currently there are 30 states (including District of Columbia) with RPSs that provide financial support for electricity production from direct and co-fired biomass combustion however to date they have had only minor effect on agricultural land use (White et al. 2013). In the Midwestern US, there are no state level policies beyond the RPSs. An additional consideration, however, in the US is the role of federally-supported crop insurance that buffers the impacts of weather/climate change on agriculture and may reduce impetus to adapt. This crop insurance does not apply to the majority of producers in Yolo County (California) as it is not available for specialty crops.

3. Methods

This project involved the comparison of survey data on farmers' responses to climate change in Scotland, Iowa, California, New Zealand (two sites) and Australia. Survey questionnaires were reviewed by the research team, where the purpose of the review was to identify questions which tapped into similar concepts. Four distinct themes were identified by the research team: (1) belief that climate change is occurring, (2) belief that climate change is caused by humans, (3) perceived risk from climate change, and (4) support for adaptation and/or mitigation initiatives. All the questionnaires used a five point scale but the questions and the response categories varied somewhat across questionnaires. Missing data were coded to system missing. In addition to allowing for a score of 1 to 5, some questionnaires allowed for a "*don't know"* response. While a legitimate response in itself, the *don't know* option was not available in all questions. Since the purpose of this study was to establish the comparison of attitudes across countries, responses recorded as *don't know* were also coded to system missing. Basic descriptive analyses were conducted on the four sets of questions. The exact wording of survey questions, answer options and the percent agreement with each question can be seen in Table 2.

4. Results and Discussion

Moving into the results section, it is important to stress that, as can be noted in Table 2, except in New Zealand and California, the survey questions asked in the different locations were not identical. The results are included in Table 2 and Figure 1.

4.1 Beliefs about climate change and its causation

Each survey contained a question about basic belief in climate change. Everywhere but Scotland, the question was a factual question about whether the climate was changing. In Scotland, the question was whether climate change was an important environmental issue. It should be noted that a survey respondent could believe the climate was changing but not consider it to be an important environmental issue. The highest level of belief was in Australia and the lowest level was in New Zealand. Interestingly, the two regions of the US were quite different with 66% of surveyed Midwestern farmers believing in climate change and only 54% of California farmers indicating belief.

Drilling down a little deeper, the surveys asked about the cause of climate change. Again, the question asked in Scotland was different in nature than the questions asked in the other locations. In Scotland, beliefs about humans' role in climate change were measured through dairy farmers' agreement or disagreement with the statement, "dairy farming contributes to climate change." Perhaps for this reason, belief in anthropogenic climate change is lowest among Scottish farmers who did not see themselves as producers of something negative. As with general belief in climate change, the Australian farmers were also more likely to believe in anthropogenic climate change than the other farmers. The higher levels of belief encountered in Australian farmers is perhaps due to the fact that Australia has suffered the most from climate change to date. Unsurprisingly, belief in the anthropogenic nature of climate change was lower everywhere than overall belief in climate change.

It is useful to consider how the varying climate change policies within these regions could be associated with overall belief in climate change among farmers within the regions. It is notable that the two regions that have actual climate change policies (California and New Zealand) are also the regions with the lowest overall belief in climate change. While a number of studies have found that climate change belief influences individual support for climate change policies (Krosnick 2006; Leiserowitz 2006) it is worth considering that the reverse may be true. Recent analysis of the California survey data by Niles et al. (2013a), showed that farmers' negative perceptions of environmental policies were a larger driver of their (dis)belief in climate change than their actual experiences with climate change. The implementation of these policies within New Zealand and California did not occur within a vacuum; in both cases it drew national attention to climate change and for many farmers brought fear about the potential increase in regulations associated with such policies. In fact, in both of these regions, farmers indicated that climate change policies were more concerning to them than biophysical climate change risks associated with temperature and water changes (Niles et al. 2013a, 2013b). By denying climate change, many farmers may feel they are safeguarding their businesses from the potential legislation that could emerge if climate change were to be recognized as a viable threat. However, only the New Zealand and California surveys were expressly written to test this hypothesis and it is not possible to say if these findings hold true for the other locations.

4.2 Perceived Risks from Climate Change and Support for Adaptation

Scottish farmers are most concerned about threats from climate change, with 45% of them agreeing that "climate change will lead to increasing productivity losses due to diseases and pests." Midwestern farmers are the least concerned with only 22% of them thinking their farm operation will be harmed by climate change. It is interesting that so few Midwestern farmers are concerned about risks from climate change despite the relatively high percentage who believe that climate change is occurring. It is possible that this lack of concern in this region is linked to crop insurance which can distort risk signals and remove incentives to invest in adaptation (Olmstead and Kleinschmit 2011 but see Weinberg 2013 for an alternative perspective). New Zealand farmers' risk perceptions varied substantially between sites; 41% of Hawkes bay respondents agreed that climate change poses more risks than benefits to agriculture compared to 32% of Marlborough farmers. We find across regions that farmer's perceptions of climate change risk are lower than their belief in climate change. This is in line with recent work on climate change perceptions that finds that people often perceive it to be a distant problem (Spence et al. 2012; Niles et al. 2015).

There was substantial support for adaptation across regions. Farmers in the Midwest are more supportive of adaptation strategies than farmers in other regions. Among California farmers only 29% said that “climate change posed more risks than benefits to agriculture” in their region. Despite the relatively low risk perceptions, 48% of respondents expressed willingness to participate in government incentive programs for climate change adaptation and mitigation. In New Zealand there was a unique pattern that the concern for local climate impacts in Marlborough was not proportional to support for adaptation measures. Forty-one percent of farmers in Hawke’s Bay indicated concern for local climate change impacts to agriculture compared with 32% in Marlborough; however, Marlborough farmers were more likely to support adaptation/mitigation measures with 49% indicating they would participate in a government incentive program compared with only 42% in Hawke’s Bay. This difference in Marlborough might be explained by the large number of surveyed farmers working in the wine industry, which tends to have an overall higher rate of adoption of climate-related practices and participation in sustainability programs.

There was no question from the Australian survey that could be compared for attitudes towards adaptation and mitigation. For the remaining locations, the Midwestern US was most likely to agree that changing practices would be important for long-term success. Note, however, that this question asked about “climate variability” not “climate change” which may well have influenced respondents’ answers. Scottish farmers were least likely to plan to adapt although this question was asked more narrowly than those in other locations and focused solely on re-assessing business objectives.

5. Conclusions

While there are a number of differences in results between the six locations, several similarities point to conclusions with global implications for farming and climate change policy. Although a majority of farmers in all the locations believed that climate change is occurring, the percentages relative to the total population were still quite low. And far fewer farmers believed that climate change is anthropogenic. Fewer still perceived climate change to be a threat to agriculture, and a minority of farmers express support for adaptation or mitigation actions. There may be many reasons for this particularly as noted earlier that near-term effects of climate change can be masked by incremental changes in technology, policy as well as by market adjustments. Thus there could well be a lag in any remedial pressure that farmers may experience. Still, given that the survey sites represent a substantial proportion of global agricultural production, these findings may be cause for concern.

In all the studied locations, there may be some climate change related benefits (e.g. warmer temperatures in higher latitudes conceivably benefit yields) to agricultural production. However, as discussed earlier, the scientific literature regarding the effects of climate change point to an overall negative impact on agriculture in the regions in question. Our assessment of the data suggests that high-income country farmers are under-prepared to mitigate risk and/or actual yield loss or be positioned to efficiently take advantage of any advantages associated with the predicted impacts of climate change.

The findings of this work suggest that such information needs to be better disseminated to the agricultural community to induce and guide adaptive measures. Additionally the consistent findings of these studies that belief in the anthropogenic nature of climate change is lower than overall belief in climate change suggests that exchanges around the need to adapt will be easier to have than conversations about the need to mitigate in all locations.

It seems likely that that climate change impacts and policies can influence farmers' beliefs about climate change. For example, in Australia where climate change impacts have been the greatest, farmers are more likely to believe in both climate change and the anthropogenic nature of climate change. In the Midwestern United States where crop insurance provides a financial buffer against weather hazards for large-scale corn producers, farmers are not overly concerned about risks from climate change. This result suggests that these climate change impact signals in some regions could be moderated by technology, policy, and market related drivers. In New Zealand and California where there are actual policies addressing climate change, farmers are least likely to believe that climate change is occurring. Further study is still warranted, however, to clearly determine a link between the influence of policy and climate change impacts on farmers' beliefs.

There are a couple of ways that comparative studies like this might be improved in the future. Clearly, there should be more location-specific information concerning risk perceptions, which address attitudes towards adaptation strategies. These strategies will be location specific but can be generalized across countries with similar agricultural conditions as the highly industrialized systems presented here. Secondly, there would be some mileage in exploring the influence and 'feedback' mechanisms of climate change beliefs in policy makers and how these shape the 'cultural' aspects of climate change within these different locations.

Finally, this paper has attempted to collate the results from a number of questionnaires representing different regions. It is clear that conclusions would be stronger if the same questions had been asked in each survey, which is challenging to undertake. For instance, in order to develop a consistent set of questions, localized cultural norms would have to be considered. However, this process had already been applied between the California and New Zealand case studies showing significant similarities across both regions. Accordingly, we believe that implementing a core set of questions across different regions would increase our understanding of how farmers across high-income countries perceive climate change. These core questions should cover general beliefs and risk perceptions towards farming and climate change, as well as responsibility towards practices which may mitigate greenhouse gas emission.

6. References

Adger WN, Arnell NW, Tompkins EL (2005) Successful adaptation to climate change across scales. Global Environmental Change 15, no. 2: 77–86.

Andresen JA, Alagarswamy G, Guentchev G, Perdinan, Piromsopa K, Pollyea A, Van Ravensway J, Winkler JA (2013) Potential impacts of climate on row crop production in the Great Lakes Region, Chapter 6. Climate Change in the Midwest Impacts, Risks, Vulnerability, and Adaptation, pp. 82-91.

Arbuckle GJ, Prokopy LS, Haigh T, Hobbs J, Knoot T, Knutson C, Loy A et al. (2013) Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States. Climatic Change 117, no. 4: 943–950.

Barnes AP, Willock J, Hall C, Toma L (2009) Farmer perspectives and practices regarding water pollution control programmes in Scotland. Agricultural Water Management. 96:1715-1722.

Barnes A, Toma L (2012). A typology of dairy farmer perceptions towards climate change. Climatic Change 112:507-522.

Barnett C, Hossell J, Perry M, Procter C, and Hughes G (2006) A handbook of climate trends across Scotland. SNIFFER project CC03, Scotland & Northern Ireland Forum for Environmental Research, pp. 66.

Barnett TP, Pierce DW, Hidalgo H, Bonfils C, Santer B, Das T, Bala G, Wood A, Nozawa T, Mirin A, Cayan D, Dettinger M (2008) Human-induced changes in the hydrology of the western United States. *Science*, 316(102): 1080–1083.

Beddington J, Asaduzzaman M, Clark M, Fernández A, Guillou M, Jahn M, Erda L, Mamo T, Van Bo N, Nobre CA, Scholes R, Sharma R, Wakhungu J (2012) Achieving food security in the face of climate change: final report from the commission on sustainable agriculture and climate change. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Brekke L, Dettinger M, Maurer E, Anderson M (2008) Significance of model credibility in estimating climate projection distributions for regional hydroclimatological risk assessments. Climatic Change, 89(3):371–394.

Brown M, Funk C (2008) Food Security Under Climate Change. Science 319: 580–581.

Bryant CR, Smit B, Brklacich M, Johnston TR, Smithers J, Chiotti Q, Singh B (2000) Adaptation in Canadian agriculture to climatic variability and change. Climatic Change 45: 181-201.

California Department of Water Resources. (2008) Managing an uncertain future: climate change adaptation strategies for California's water. California Department of Water Resources, Sacramento, CA.

CARB (California Air Resources Board). (2008) Climate change proposed scoping plan. Sacramento, CA: California Environmental Protection Agency, Air Resources Board.

CARB (California Air Resources Board). (2013) California Greenhouse Gas Inventory for 2000-2011 by Category as Defined by the 2008 Scoping Plan, Sacramento, CA: California Environmental Protection Agency, Air Resources Board. Available at: http://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_scopingplan_00-11_2013-08-01.pdf

Cayan DR, Maurer EP, Dettinger MD, Tyree M, Hayhoe K (2008) Climate change scenarios for the California region. *Climatic Change*, 87(1): S21–S42.

Cayan DR, Das T, Pierce DW, Barnett TP, Tyree M, Gershunov A (2010) Hydrology of the early 21st century Southwest drought: possible harbinger of future decades. *Proceedings of the National Academy of Sciences of the United States of America*, 107(50): 21271–22126.

Chaplin-Kramer R, George MR (2013) Effects of Climate Change on Range Forage Production in the San Francisco Bay Area. PLoS ONE 8(3): e57723.

Clark AJ, Nottage RAC, Wilcocks L, Lee JM, Burke C, Kalaugher E, Roche J, Beukes P, Lieffering M, Newton PCD, Li FY, Vibart R, Teixeira EI, Brown HE, Fletcher AL, Hernandex-Ramirez G, Soltani A, Viljanen-Rollinson S, Horrocks A, Johnstone P, Clothier B, Hall A, Green S, Dunningham A, Kirschbaum MUF, Meason D, Payn T, Collins DBG, Woods RA, Rouse H, Duncan M, Snelder T, Cowie B. (2012) Impacts of climate change on land-based sectors and adaptation options. Clark AJ, Nottage RAC, Hansford D (eds). Stakeholder Report to the Sustainable Land Management and Climate Change Adaptation Technical Working Group. Ministry for Primary Industries. pp. 76.

Climate Change Response (Emissions Trading and Other Matters). Amendment Act (2012) Public Act No 89. November 13, 2012.

Coumou D, Rahmstorf S (2012) A Decade of Weather Extremes. Nature Climate Change, 2, 491-496.CSIRO & BoM. 2007. Climate change in Australia: Technical report 2007. CSIRO, Melbourne.

CSIRO. (2011) Baseline Survey of Australian attitudes to climate change: PRELIMINARY REPORT. Leviston, Z. and Walker, I.A. Social & Behavioural Sciences Research Group (online) http://www.csiro.au/en/Outcomes/Climate/Adapting/Annual-Survey-of-Australian-Attitudes-to-Climate-Change.aspx

Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education. (2013) The carbon farming initiative (online) http://www.climatechange.gov.au/reducing-carbon/carbon-farming-initiative.

Dwyer J, Clark M, Kirwan J et al. (2008) Review of Rural Development Instruments: DG Agri project 2006-G4-10. European Commission, Brussels.

Garnaut R (2011) The Garnaut review 2011: Australia in the global response to climate change. Cambridge University Press.

Gbetibouo GA (2009). Understanding farmers' perceptions and adaptations to climate change and variability: the case of the Limpopo Basin, South Africa, IFPRI. Discussion Paper. Washington, DC: International Food Policy Research Institute.

Gramig B, Barnard JB, Prokopy LS (2013) Farmer beliefs about climate change and carbon sequestration incentives. Climate Research. 56: 157-167.

Gwimbi P (2009) Cotton farmers' vulnerability to climate change in Gokwe District (Zimbabwe): impact and influencing factors. J Disaster Risk Stud 2: 81-92.

Haden VR, Niles MT, Lubell M, Perlman J, Jackson LE (2012) Global and Local Concerns: What Attitudes and Beliefs Motivate Farmers to Mitigate and Adapt to Climate Change? PLoS ONE 7, no. 12: e52882.

Haden VR, Dempsey M, Wheeler S, Salas W., Jackson LE (2013) Use of local greenhouse gas inventories to prioritise opportunities for climate action planning and voluntary mitigation by agricultural stakeholders in California. Journal of Environmental Planning and Management 56, no. 4: 553–571.

Harrington LMB, Lu M. (2002) Beef feedlots in southwestern Kansas: local change, perceptions and the global change context. Global Environmental Change. 273-282.

Hawkes Bay Regional Council. (online) http://www.hbrc.govt.nz/Pages/default.aspx

Hogan A, Berry HL, Ng SP, Bode A (2011) Decisions made by farmers that relate to climate change. Agricultural Science, Vol. 23, No. 1: 36-39.

Holt CA, Shobe WM (2013) Investigation of the effects of emission market design on the market-based compliance mechanism of the California cap on greenhouse gas emissions (No. 2013-01). Center for Economic and Policy Studies.

Howden SM, Soussana JF, Tubiello FN, Chhetri N, Dunlop M, Meinke H (2007) Adapting agriculture to climate change. Proceedings of the National Academy of Sciences*, 104*(50), 19691-19696.

IPCC. (2007) Climate change 2007: Synthesis report, summary for policymakers. In RK Pachauri & A Reisinger. (Eds.), Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva: Intergovernmental Panel on Climate Change.

Jackson L, Haden VR, Hollander AD, Lee H, Lubell M, Mehta VK, O'Geen T, Niles M, Perlman J, Purkey D, Salas W, Sumner D, Tomuta M, Dempsey M, Wheeler SM (2012) Adaptation Strategies for Agricultural Sustainability in Yolo County, California. California Energy Commission, 183 p, Publication number CEC-500-2011-031.

Kingwell R (2006). Climate change in Australia: agricultural impacts and adaptation. *Australian Agribusiness Review*, *14*(1).

Krosnick J, Holbrook A, Lowe L, Visser P (2006) The origins and consequences of democratic citizens' policy agendas: A study of popular concern about global warming. Climatic Change. 77:7-43.

Lal R, Delgado JA, Groffman PM, Millar N, Dell C, Rotz A. (2011) Management to mitigate and adapt to climate change. Journal of Soil and Water Conservation 66, no. 4: 276–285.

Leiserowitz A (2006) Climate change risk perception and policy preferences: The role of affect, imagery, and values. Climatic Change. 77:45-72.

Lobell DB, Cahill KN, Field CB (2007) Historical effects of temperature and precipitation on California crop yields. *Climatic Change*, 81: 187-203.

Lobell DB, Field CB, Cahill KN, Bonfils C (2006) Impacts of future climate change on California perennial crop yields: Model projections with climate and crop uncertainties. Agricultural and Forest Meteorology 141: 208-218.

Lobell DB, Field CB (2007) Global scale climate–crop yield relationships and the impacts of recent warming. Environmental Research Letters 2, no. 1: 014002.

Lobell DB, Burke MB, Tebaldi C, Mastrandrea MD, Falcon WP, Naylor RL (2008) Prioritizing climate change adaptation needs for food security in 2030. Science 319, no. 5863: 607–610.

Lobell DB, Gourdji SM (2012) The influence of climate change on global crop productivity. Plant Physiology 160, no. 4: 1686–1697.

Maddison DJ (2007) The perception of and adaptation to climate change in Africa. World Bank Policy Research Working Paper No. 4308.

Malcolm S, Marshall E, Aillery M, Heisey P, Livingston M, Day-Rubenstein K (2012) Agricultural adaptation to a changing climate: economic and environmental implications vary by U.S. region, ERR-136, U.S. Department of Agriculture, Economic Research Service, July 2012.

Marlborough District Council. Marlborough Region Land and Water Areas (online) http://www.marlborough.govt.nz/About-Marlborough/Regional-Information/Land-Areas.aspx;

Mertz O, Mbow C, Reenberg A, Diouf A (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in Rural Sahel. Environmental Management 43, 804-816

McCarl BA (2010) Analysis of climate change implications for agriculture and forestry: an interdisciplinary effort. Climatic Change, 100, no. 1: 119-124.

National Institute for Water and Atmosphere. 2008. Climate Change Projections for New Zealand (online) http://www.niwa.co.nz/sites/default/files/import/attachments/IPCC_08_report_02s.pdf

New Zealand Ministry for Agriculture and Forestry. (2011) A Guide to Reporting for Agricultural Activities Under the New Zealand Emissions Trading Scheme.

New Zealand Ministry for Environment. (2008) Climate change effects and impacts assessment. A Guidance Manual for Local Government in New Zealand. 2nd Edition. Prepared by Mullan, B., Wratt, D., Dean, S., Hollis, M., Allan, S., Williams, T., Kenny, G. National Institute for Water and Atmosphere Client Report WLG2007/62. pp. 156

New Zealand Ministry for the Environment. (2012b) Forestry in the Emissions Trading Scheme (online) http://www.climatechange.govt.nz/emissions-trading-scheme/participating/forestry/

New Zealand Ministry for Primary Industries. (2013) Agriculture and the Emissions Trading Scheme (online) http://www.mpi.govt.nz/agriculture/agriculture-ets

Nicholls N (2004) The changing nature of Australian droughts. Climatic Change 63: 323–36.

Niemeier DA, Rowan D. (2009) From kiosks to megastores: the evolving carbon market. California Agriculture, 63(2): 96–103.

Nigg J M, Mileti D (2002) Natural hazards and disasters. In R. E. Dunlap & W. Michelson (Eds.), Handbook of Environmental Sociology pp. 272-294. Westport, CT: Greenwood Press.

Niles MT, Lubell M, Haden VR (2013a) Perceptions and responses to climate policy risks among California farmers. Global Environmental Change. 23: 1752-1760.

Niles MT, Brown M, Dynes R, Lubell M (2013b) Understanding New Zealand and California farmer attitudes to climate change policy. Presentation at the New Zealand Climate Change Conference (online) http://www.nzcccconference.org/images/custom/niles,_meredith-_ok.pdf

Niles MT, Lubell M, Brown M (2015) How limiting factors drive agricultural adaptation to climate change. Agriculture, Ecosystems and Environment. 200 (1): 178-185.

OECD/Food and Agriculture Organization of the United Nations (2013) OECD-FAO Agricultural Outlook 2013. OECD Publishing. DOI:10.1787/agr_outlook-2013-en.

Olmstead J, Klienschmit J (2011). A risky proposition: Crop insurance and climate change adaptation. Institute for Agriculture and Trade Policy.

Pryor SC, Barthelmie RJ (2013) Climate change impacts, risks, vulnerability, and adaptation in the midwestern united states: what next? Chapter 17. Climate Change in the Midwest Impacts, Risks, Vulnerablitity, and Adaptation. pp. 230-257.

Rejesus RM, Mutuc-Hensley M, Mitchell PD, Coble KH, Knight TO (2013) U.S. agricultural producer perceptions of climate change. Journal of Agriculture and Applied Economics: 701-718.

Rowlinson P (2008) Adapting livestock production systems to climate change temperate zones. Livestock and Global Change conference proceedings, May 2008, Tunisia.

Rural and Environmental Science and Analytical Services (RESAS) (2013) Results from the June 2012 Agricultural Census. Scottish Government, Edinburgh, UK.

Schnepf R, Yacobucci B (2013) Renewable Fuel Standard (RFS): Overview and Issues. Washington D.C.: Congressional Research Service.

Scottish Government (2013) Low carbon Scotland: Meeting our emissions reduction targets 2013-2027. The Second Report on Proposals and Policies.

Smit B, Skinner MW (2002) Adaptation Options in Agriculture to Climate Change: a Typology. Mitigation and Adaptation Strategies for Global Change 7, no. 1: 85–114.

Smith, P, Olesen JE (2010) Synergies between the mitigation of, and adaptation to, climate change in agriculture. Journal of Agricultural Science 148, no. 5: 543–552.

Spence, A , Poortinga W, Pidgeon NF (2012) The psychological distance of climate change. Risk Analysis 32, no.6: 957-972.

Statistics New Zealand (2012) Census of agriculture. Agricultural Area in Hectares by Usage and Region.

Stubbs M (2010) Biomass crop assistance program (BCAP): status and issues. Washington D.C.: Congressional Research Service.

Stuff New Zealand Business Day. (2010) Petrol Prices Rise as ETS Starts to Bite (online) http://www.stuff.co.nz/business/industries/3873271/Petrol-prices-rise-as-ETS-starts-to-bite.

Thornton PK, van de Steeg J, Notenbaert A, Herrero M (2009) The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. Agricultural Systems 101, 113-127.

USDA Farm Service Agency (FSA) (2013) BCAP biomass crop assistance program energy feedstocks from farmers and foresters. Washington DC.

USDA-NASS (U.S. Department of Agriculture National Agricultural Statistics Service) (2009) 2007 census of agriculture. Washington, DC: U.S. Department of Agriculture National Agricultural Statistics Service.

USEPA.(2013) Inventory of U.S. greenhouse gas emissions and sinks: 1990-2011. Washington, DC: US Environmental Protection Agency.

Walthall CL, Hatfield J, Backlund P, Lengnick L, Marshall E, Walsh M, Adkins S, Aillery M, Ainsworth EA, Ammann C, Anderson CJ, Bartomeus I, Baumgard LH, Booker F, Bradley B, Blumenthal DM, Bunce J, Burkey K, Dabney SM, Delgado JA, Dukes J, Funk A, Garrett M, Glenn DA, Grantz D, Goodrich S, Hu RC, Izaurralde RAC, Jones S.H., Kim ADB, Leaky K, Lewers K, Mader TL, McClung A, Morgan J, Muth DJ, Nearing M, Oosterhuis DM, Ort D, Parmesan C, Pettigrew WT, Polley W, Rader R, Rice C, Rivington M, Rosskopf E, Salas WA, Sollenberger LE, Srygley R, Stöckle C, Takle ES, Timlin D, White JW, Winfree R, Wright-Morton L, Ziska, LH (2012) Climate change and agriculture in the United States: effects and adaptation. USDA Technical Bulletin 1935. Washington, D.C. 186 pages (online) http://www.usda.gov/oce/climate_change/effects_2012/CC%20and%20Agriculture%20Report%20%2802-04-2013%29b.pdf

Weinberg M, Meybeck A, Lankoski J, Redfern S, Azzu N, Gitz V (2012). Agricultural response to a changing climate: the role of economics and policy in the United States of America. In *Building resilience for adaptation to climate change in the agriculture sector. Proceedings of a Joint FAO/OECD Workshop, Rome, Italy, 23-24 April 2012.* (pp. 345-346). Food and Agriculture Organization of the United Nations (FAO).

Wheeler S, Zuo A, Bjornlund H (2013) Farmers' climate change beliefs and adaptation strategies for a water scarce future in Australia. Global Environmental Change: 537-547.

White EM, Latta G, Alig RJ, Skog KE, Adams DM (2013). Biomass production from the US forest and agriculture sectors in support of a renewable electricity standard. Energy Policy.

Table 1. Comparison of Study Locations across Key Variables

	US - California	US - Midwest	NZ - Marlborough	NZ – Hawkes Bay	Australia	Scotland
Survey conducted (year)	2011	2012	2012	2012	2008	2009
Number of Respondents	162	4,778	177	313	3,993	551
Geographic Scope of survey	County	Regional	Regional	Regional	Nationally representative	Farming
Type of Production System Surveyed	All (including grain and field, vegetable, orchards, vineyards and horticulture)	Corn producers with greater than 80 acres of corn production and minimum of US$100,000 gross sales	All (majority wine)	All (majority sheep, beef, deer)	All (including row crop, livestock and specialty crops)	Dairy
Climate Regime	Mediterranean	Temperate	Temperate	Temperate	Very mixed	Temperate
Agricultural Systems					Yes	
Percent of GDP from agriculture[1]	US – 1.1%	US – 1.1%	NZ - 4.8%	NZ - 4.8%	Aust. - 4%	UK - 0.7%
Percent of total national or state GHG emissions from agriculture2	CA - 7.2% US - 6.9%	US - 6.9%	NZ - 47.2%	NZ - 47.2%	Aust. – 16^	UK - 12%
Climate Policy Instruments						
Regulation-based						
Compliant with Kyoto Protocol	US – No CA - Yes	No	Yes at date of survey, but did not renew as of 12/2012	Yes at date of survey, but did not renew as of 12/2012	Yes	Yes
GHG reporting for farmers	No	No	No	No	No	No
GHG reporting for agricultural processors	Yes	No	Yes	Yes	No	Yes
Economic & Market-based						
Govt. incentive programs	Yes	Yes	No	No	Yes	Yes
Farm subsidies	Yes	Yes	No	No		
Market-based climate mitigation program	Yes	No	No, but emissions trading scheme	No, but emissions trading scheme	No	No

[1] Agricultural GDP data is for 2012. Source: CIA Factbook: https://www.cia.gov/library/publications/the-world-factbook/

[2] Sources of information for GHG emissions: USEPA 2013; CARB 2013, http://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_scopingplan_00-11_2013-08-01.pdf; New Zealand Greenhouse Gas Inventory 1990-2011. Ministry for the Environment, http://www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2013/; CSIRO, http://www.csiro.au/science/Carbon-Australian-agriculture

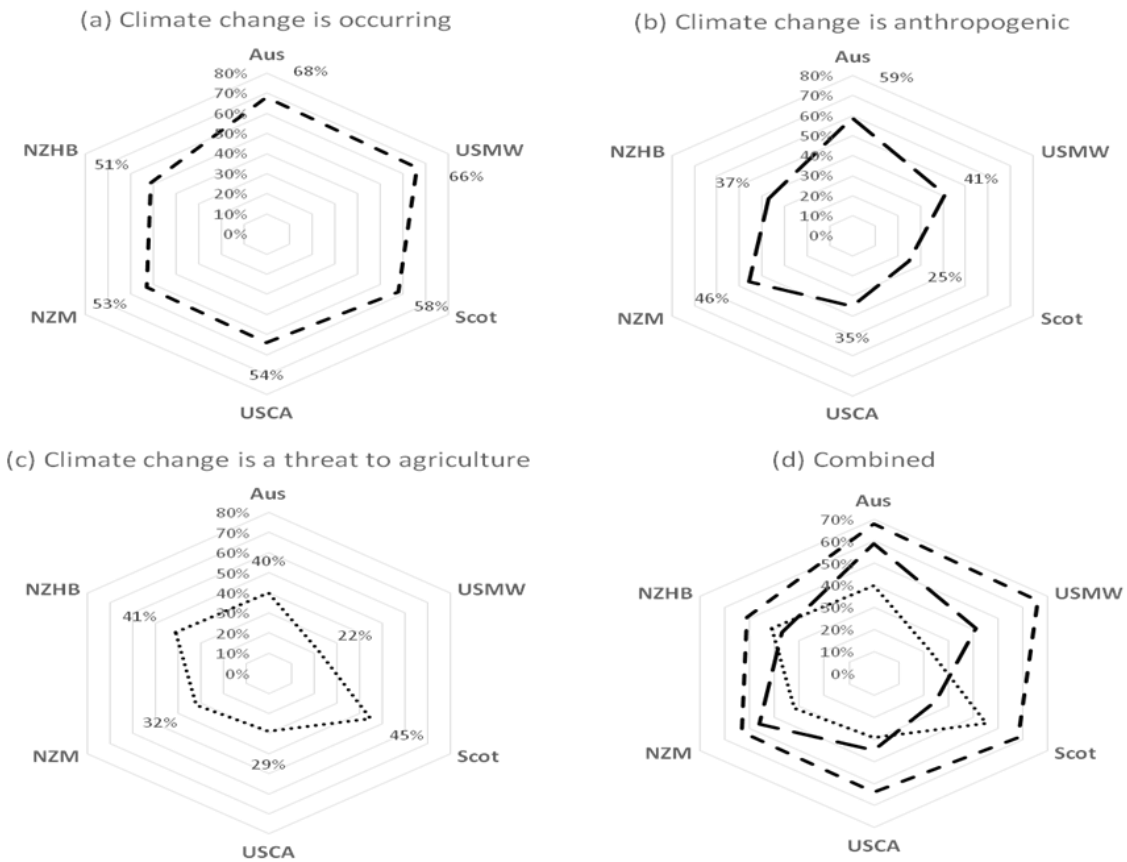
Table 2: Survey Questions and Results

Country	Question	Answer Options	Percent agreement
	Climate change is occurring		
Australia	Climate patterns really are changing.	5 point scale: false – true.	68%
New Zealand – HB	The global climate is changing.	5 point scale: strongly disagree – strongly agree. Don't know option.	51%
New Zealand – M	Same as NZ-HB		53%
Scotland	Climate change is an important environmental issue.	5 point scale: strongly disagree – strongly agree. Don't know option.	58%
U.S. – California	Same as NZ-HB		54%
U.S. – Midwest	There is increasing discussion about climate change and its potential impacts. Please select the statement that best reflects your beliefs about climate change.	5 options. Percent presented here include farmers who answered either: (1) climate change is occurring, and it is caused mostly by natural changes in the environment, (2) climate change is occurring, and it is caused mostly by human activities, (3) climate change is occurring, and it is caused more or less equally by natural changes in the environment and human activities.	66%
	Climate change is anthropogenic		
Australia	Carbon emissions worsen the effects of natural climate cycles.	5 point scale: false - true	59%
New Zealand – HB	Human activities such as fossil fuel use are an important cause of climate change.	5 point scale: strongly disagree – strongly agree. Don't know option.	37%
New Zealand – M	Same as NZ-HB		46%
Scotland	Dairy farming contributes to climate change.	5 point scale: strongly disagree – strongly agree. Don't know option.	25%
U.S. – California	Same as NZ-HB		35%
U.S. – Midwest	There is increasing discussion about climate change and its potential impacts. Please select the statement that best reflects your beliefs	5 options. Percent presented here include farmers who answered either: (2) climate change is occurring, and it is caused mostly	41%

	about climate change.	by human activities, (3) climate change is occurring, and it is caused more or less <u>equally</u> by natural changes in the environment and human activities.	
	Climate change is a threat to agriculture		
Australia	Climate change is threatening the viability of my property.	5 point scale: false – true.	40%
New Zealand – Hawkes Bay	Climate change poses more risks than benefits to agriculture in Hawkes Bay.	5 point scale: strongly disagree – strongly agree. Don't know option.	41%
New Zealand – Marlborough	Climate change poses more risks than benefits to agriculture in Marlborough.	5 point scale: strongly disagree – strongly agree. Don't know option.	32%
Scotland	Climate change will lead to increasing productivity losses due to diseases and pests.	5 point scale: strongly disagree – strongly agree. Don't know option.	45%
U.S. – California	Climate change poses more risks than benefits to agriculture in Yolo County.	5 point scale: strongly disagree – strongly agree. Don't know option.	29%
U.S. – Midwest	My farm operation will likely be harmed by climate change.	5 point scale: strongly disagree – strongly agree.	22%
	Support for Adaptation/Mitigation		
Australia	NA		
New Zealand – Hawkes Bay	I would participate in government incentive programs for climate change mitigation or adaptation.	5 point scale: strongly disagree – strongly agree. Don't know option.	42%
New Zealand – Marlborough	Same as NZ-HB		49%
Scotland	The threat from climate change forces me to re-assess my business objectives.	5 point scale: strongly disagree – strongly agree. Don't know option.	20%
U.S. – California	Same as NZ-HB	5 point scale: strongly disagree – strongly agree. Don't know option.	48%
U.S. – Midwest	(Adaptation) Changing my practices to cope with increasing climate variability is important for the long-run success of my farm. (Mitigation) Government should do more to reduce greenhouse gas emissions and other	5 point scale: strongly disagree – strongly agree.	(adaptation) 53% (mitigation) 23%

	potential sources of climate change.

Figure 1: Radar Graphs Displaying Differences between Regions



This figure illustrates the differences in percentages of farmers who believe : (a) climate change is occurring – represented by a blue line, (b) climate change is anthropogenic – represented by a red line, and (c) climate change is a threat to agriculture – represented by a green line. (d) combines all these beliefs onto one radar graph. Aus = Australia; USMW = Midwestern United States; Scot = Scotland; USCA = California USA; NZM = Marlborough, New Zealand; NZHB = Hawkes Bay, New Zealand.